(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 807 958 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
30.10.2002 Bulletin 2002/44

(51) Int Cl.[7]: **H01J 61/44**, H01J 61/48

(21) Application number: **97303239.4**

(22) Date of filing: **13.05.1997**

(54) Fluorescent lamp with phosphor coating of multiple layers

Fluoreszente Lampe mit mehrschichtigem Phosphorüberzug

Lampe fluorescente ayant un revêtement luminescent multicouche

(84) Designated Contracting States:
DE FR GB IT

(30) Priority: **13.05.1996 US 644441**

(43) Date of publication of application:
19.11.1997 Bulletin 1997/47

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EP 0 807 958 B1

Printed by Jouve, 75001 PARIS (FR)

Description

[0001] The present invention relates generally to fluorescent lamps and more particularly to a low pressure mercury vapor discharge fluorescent lamp having a rare earth phosphor coating.

[0002] With regard to low pressure mercury vapor fluorescent lamps, it is known to use straight or cylindrical glass tubes and bent or non-straight glass tubes in the final lamp configuration. An example of the latter is a compact fluorescent lamp made with cylindrical straight tubing which is bent in manufacturing. With respect to lamps with non-straight tubes or glass envelopes, such lamps can be coated with phosphor before or after forming or bending of the glass tubing. If the forming is completed before the phosphor is coated on the inner surface of the tubing via a suspension, the suspension may not drain completely. In some configurations phosphor will settle preferentially to the bottom of a bend during draining. Even when drained by being rotated or shaken or otherwise moved in a complex fashion or by applying air pressure, the coating is often very non-uniform.

[0003] One solution to this problem is to first complete the coating of the phosphor on the straight tubing and then form the tubing to its final lamp configuration. However, this has been done with relatively thick single layers or coatings of phosphor (the single layer being of sufficient thickness to absorb substantially all the UV generated by the arc), but this single layer of phosphor tends to flake or partially come off in sections where the tube is formed or bent around a radius of curvature. What is needed is a procedure or approach which will result in the phosphor coating adhering better and not flaking or coming off in sections where the tube is bent or formed, during the forming procedure.

According to the invention, there is provided a low pressure mercury vapor discharge lamp comprising a tubular non-straight glass envelope having a bent section formed after a coating step, means for providing a discharge, a discharge-sustaining fill of mercury and an inert gas sealed inside said envelope, and a plurality of rare earth phosphor layers coated inside said glass envelope, each of said plurality of phosphor layers (1) being comprised of rare earth phosphor particles, and (2) being 1 to 3 particles thick, said plurality of layers consisting of 2 to 6 layers.

[0004] A method of making the invented low pressure mercury vapor discharge lamp is also provided.

[0005] Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 shows diagrammatically, broken, and partially in section, a glass envelope or tube of a low pressure mercury vapor discharge fluorescent lamp according to the present invention.

Fig. 2 shows an elevational view, with part of the housing broken away, of a helical compact fluorescent lamp for use with the invention.

Fig. 3 shows a top view of the helical compact fluorescent lamp of Fig.

[0006] As used in the specification and claims, "formed", "form", or "forming", with respect to glass envelopes or glass tubing, means bending or reshaping such as by heating the glass tube to its softening point and bending or reshaping it and then letting it cool in its new shape or configuration; "coating weight" is determined or calculated after lamp-making is completed; and "non-straight glass envelope" includes (but is not limited to) a glass envelope or tube which is in the shape of an L or a U (such as a 4 foot T8 or T12 lamp bent into a U-shape), a circular glass envelope as is known in the art, the glass envelope of a compact fluorescent lamp, particularly a helical compact fluorescent lamp, and other glass envelopes which are not a straight cylindrical glass envelope. Compact fluorescent lamps are well known; see US-A-2,279,635; US-A-3,764,844; -3,899,712; -4,503,360; -5,128,590; -5,243,256; U.S. Patent Application Serial No. 08/414,077 filed March 31, 1995; and DE-A-4133077 filed in Germany on October 2, 1991.

[0007] Fig. 1 shows diagrammatically a representative glass envelope or tube of a low pressure mercury vapor discharge fluorescent lamp 10. The broken lines indicate that a section is omitted; in the present invention a non-straight or bent portion would be where the omitted portion is located. The fluorescent lamp 10 has a light-transmissive glass envelope or tube 12 which preferably has a circular or oval cross section. Different envelopes frequently have different diameters. A compact fluorescent lamp typically has a 12 mm outer diameter; other common envelopes have diameters of 25 and 37 mm. The inner surface of the glass envelope or tube is provided with a plurality of rare earth phosphor layers, preferably 2-6, more preferably 2-5, more preferably 2-4, more preferably 2-3, more preferably 2 or 3, layers. In Fig. 1, rare earth phosphor layers 13, 14, 15, 16 and 17 are shown for purposes of illustration, although more or less can be provided, but at least 2. As is known in the art, other coatings such as conductive coatings, precoats, barrier layers, and ultraviolet reflecting layers may be provided between the phosphor layers and the inner surface of the glass tube.

[0008] The lamp is hermetically sealed by bases 20 attached at both ends (as is known in the art, other types of bases 20 may be used in the lamps of the present invention). A pair of spaced electrode structures 18 (which are means for providing a discharge) are respectively mounted on the bases. A discharge-sustaining fill 22 of mercury and an inert gas is sealed inside the glass envelope. The inert gas is typically argon or a mixture of argon and other noble gases at low pressure which, in combination with a small quantity of mercury, provides the low vapor pressure manner of operation.

[0009] The present invention may be used in fluores-

cent lamps having electrodes as is known in the art, as well as in electrodeless fluorescent lamps as are known in the art, where the means for providing a discharge is a structure which provides high-frequency electromagnetic energy or radiation.

[0010] Each rare earth phosphor layer contains a rare earth phosphor system (which is typically a blend of rare earth phosphors), and does not contain halophosphate phosphors. The lamps of the present invention do not contain halophosphate phosphor layers. Rare earth phosphor systems are well-known in the art. As used in the specification and claims herein, a rare earth phosphor system includes (1) a triphosphor system such as a red, blue and green color-emitting phosphor blend as disclosed in U.S. Pats. 5,045,752; 4,088,923; 4,335,330; 4,847,533; 4,806,824; 3,937,998; and 4,431,941; and (2) phosphor blends which have other numbers of rare earth phosphors, such as systems with four or five rare earth phosphors. Any rare earth phosphor system known in the art may be used. Each rare earth phosphor layer is a traditional rare earth phosphor layer as is known in the art, except that it is particularly thin. As with traditional rare earth phosphor layers, the phosphor layers of the present invention may contain non-luminescent particles such as alumina, calcium pyrophosphate, and certain borate compounds as are known in the art.

[0011] Each rare earth phosphor layer is applied in a thin coating in a manner known in the art, preferably to a piece of straight cylindrical tubing. In the coating procedure typically the rare earth phosphor particles or powders are blended by weight. The resulting powder is then dispersed in a water vehicle (which may contain other additives as are known in the art, such as adherence promoters such as fine non-luminescent particles of alumina or calcium pyrophosphate) with a dispersing agent as is known in the art. Then a thickener is added, typically polyethylene oxide. The suspension is then typically diluted with deionized water until it is suitable for producing a coating of the desired thickness or coating weight. The suspension is then applied as a coating to the inside of the glass tube (preferably by pouring the suspension down the inside of a vertically-held tube or pumping the suspension up into same) and heated by forced air until dry, as is known in the art. After the first thin coat or layer is applied, additional thin coats or layers are applied in the same manner, carefully drying each coat before the next coat is applied. Each thin coat or layer is of the same phosphor blend or composition; thus when a tube has received all of its thin coats, each coat will be of the same phosphor blend or composition. After the last coat has been applied, the binders and other organic ingredients are baked out, as is known in the art. Then the straight tube can be heated to its softening point and formed into the desired non-straight configuration, such as to make the glass envelope for a helical compact fluorescent lamp. By the use of the invention the phosphor coating will not flake off during forming in the sections being formed or bent.

[0012] Each rare earth phosphor layer is comprised of rare earth phosphor particles, as is known in the art; preferably rare earth triphosphor blends are used. The rare earth phosphor particles used in the invention have a median particle size or diameter of preferably 1.5-9 microns, more preferably 3-6 microns, more preferably about 4 microns, and have a particle density of preferably about 4-5.5 g/cm^3, more preferably about 5 g/cm^3. Each rare earth phosphor layer has a thickness, after lamp making, of 1-3, more preferably 1.5-2.5, more preferably about 2, particles thick. By this is meant, for example, if the median particle size is 4 microns and the phosphor layer has a thickness of 2 particles, then the layer is approximately 8 microns thick. As used herein, if the median particle size is 5 microns and the phosphor layer has a thickness of 3 particles, the layer is approximately 15 microns thick, etc. When particles form a layer, the particles are touching, to the extent permitted by packing.

[0013] If a typical rare earth triphosphor blend is used, having a 4 micron median particle size and a particle density of 5 g/cm^3, and a layer 2 particles thick is applied, the coating weight of that layer on the glass envelope is about 1.3 mg/cm^2 (if a theoretical porosity factor of 0.5 is used), and about 1.9 mg/cm^2 (if a theoretical porosity factor of 0.7 is used). The theoretical porosity factor accounts for the fact that there is empty space or interstitial space among or between the touching particles. For a rare earth triphosphor blend having a 4 micron median particle size and a particle density of 5 g/cm^3, the coating weight for each layer is 1-2, more preferably 1-1.8, more preferably 1.1-1.5, more preferably 1.2-1.3, mg/cm^2; for other median particle sizes, the preferred coating weights for each layer can be obtained by multiplying the above ranges by the ratio of the new median particle size to 4 microns; for other particle densities, the preferred coating weights for each layer can be obtained by multiplying the above ranges by the ratio of the new particle density to 5 g/cm^3. If both median particle size and particle density change, the new coating weight ranges are obtained by performing both calculations. As can be seen, the preferred coating weight is a function of the median particle size and the particle density.

[0014] In the present invention the thin layers are built up until the total or cumulative coating thickness is sufficient to absorb substantially all of the UV light produced by the arc; this is typically 4-8, preferably about 6, particles thick. Preferably there are 2-6, more preferably 2-5, more preferably 2-4, more preferably 2-3, more preferably 2 or 3, rare earth phosphor layers. If 3 layers, each about 2 particles thick, are applied, this will yield a cumulative coating thickness of about 6 particles thick. The cumulative coating thickness should be such that even when stretched around the outside of the sharpest bends it remains about 4-6 particles thick. If a triphosphor blend having a 4 micron median particle size and

a particle density of 5 g/cm^3 is used, the total or cumulative coating weight is preferably at least 2.6 mg/cm^2, more preferably at least 3 mg/cm^2, more preferably at least 3.5 mg/cm^2; if other median particle sizes or particle densities are used, the preferred total or cumulative coating weights are directly proportional. If a triphosphor blend having a 4 micron median particle size and a particle density of 5 g/cm^3 is used, it is effective to apply 3 thin layers each having a coating weight of 1.2-1.3 mg/cm^2, yielding a total cumulative coating weight of 3.5-3.9 mg/cm^2.

[0015] The invention is particularly useful in preventing flaking or falling off in sections of straight tubing being bent around a radius of curvature to yield a bent portion having an inside radius of curvature of less than 65 cm, more preferably less than 30 cm, more preferably less than 15 cm, more preferably less than 7 cm, more preferably less than 3 cm, more preferably less than 15 mm, more preferably less than 7 mm, more preferably less than 3 mm, more preferably less than 1.5 mm, more preferably less than 1 mm.

[0016] It is believed that if the individual phosphor layer is 1-2 or 1-3 particles thick, it remains sufficiently flexible to bend. If it is 4-6 or more particles thick, it is too rigid. Particles in thin layers can rotate around each other when the layer is bent. The particles in each thin layer can follow the bend of the glass or the layer below and the layers themselves are separated from each other by virtue of having been coated and dried separately, and can slide slightly past each other during bending, thus avoiding flaking off.

[0017] The invention is particularly useful in the manufacture of compact fluorescent lamps, particularly helical compact fluorescent lamps, such as shown in Figs. 2-3, where a lot of forming is required. With reference to Figs. 2-3, a helical compact fluorescent lamp 30 is shown, having a lamp envelope or tube 32 in a coiled double helix configuration. End portions 32a, 32b enter the top portion 36 of the housing member 34; disposed within the end portions 32a, 32b are electrodes 38 which are electrically coupled to a ballast circuit arrangement 40 mounted within housing member 34.

[0018] The following Example further illustrates various aspects of the invention.

EXAMPLE

[0019] Straight tubes were coated or layered with a rare earth triphosphor blend having a 4 micron, median particle size and a 5 g/cm^3 particle density; these tubes were then formed into a helical compact fluorescent lamp. Thin layers of 1.5-2.0 mg/cm^2 coating weight were applied. When tubes with 2, 3, 4, and even more thin layers were formed, little or no coating was observed to come off after helical coiling even in the region at the top of the lamp where the tubing is bent around a 1/8 inch radius of curvature. This occurred even when the total or cumulative phosphor coating weight was 5-6 mg/cm^2. If a single layer was used, significant coating flaked off the envelope or tube even at about 2.6 mg/cm^3 coating weight, and it was not possible to go higher in coating weight without severe loss of phosphor over a large portion of the lamp in regions where the tubing was bent.

Claims

1. A low pressure mercury vapor discharge lamp comprising a tubular non-straight glass envelope having a bent section formed after a coating step, means for providing a discharge, a discharge-sustaining fill of mercury and an inert gas sealed inside said envelope, and a plurality of rare earth phosphor layers coated inside said glass envelope, each of said plurality of phosphor layers (1) being comprised of rare earth phosphor particles, and (2) being 1 to 3 particles thick, said plurality of layers consisting of 2 to 6 layers.

2. A lamp according to claim 1, each of said plurality of phosphor layers being of the same rare earth phosphor composition.

3. A lamp according to claim 1 or claim 2, each of said plurality of phosphor layers having a coating weight of 1 to 2 mg/cm^2.

4. A lamp according to any one of claims 1 to 3, said bent portion of said glass envelope having an inside radius of curvature of less than 15 cm.

5. A lamp according to any one of claims 1 to 4 wherein the median particle size is 1.5 to 9 gym.

6. A lamp according to any one of claims 1 to 5, wherein the total coating thickness of the phosphor layers is 4 to 8 particles thick.

7. A lamp according to any one of claims 1 to 6 wherein the plurality of phosphor layers has a total coating weight of at least 2.6 mg/cm^2.

8. A method of making a low pressure mercury vapor discharge lamp comprising the steps of: providing a straight glass tube, coating a plurality of rare earth phosphor layers inside said straight glass tube, each of said plurality of phosphor layers (1) being comprised of rare earth phosphor particles, and (2) being 1 to 3 particles thick, said plurality of layers consisting of 2 to 6 layers; subsequent to said coating step forming the glass tube into a non-straight glass envelope, and incorporating said glass envelope into a low pressure mercury vapor discharge lamp.

9. A method according to claim 8, each of said plurality

of phosphor layers being of the same rare earth phosphor composition.

10. A method according to claim 8 or claim 9, each of said plurality of phosphor layers having a coating weight of 1 to 2 mg/cm2.

11. A method according to any one of claims 8 to 10, said bent portion of said glass envelope having a having an inside radius of curvature of less than 15 cm.

12. A method according to any one of claims 8 to 11, wherein each of said plurality of phosphor layers has a coating weight within a preselected range, said pre-selected range being 1 to 2 mg/cm^2 where the median particle size is 4 microns and the particle density is 5 g/cm^3, where said median particle size is not 4 microns said pre-selected range is obtained by multiplying 1 to 2 mg/cm2 by the ratio of the median particle size to 4 microns, where said particle density is not 5 g/cm^3 said preselected range is-obtained by multiplying 1 to 2 mglcm2 by the ratio of the particle density to 5 g/cm^3, provided however that if the median particle size is not 4 microns and the particle density is not 5 g/cm^3 both calculations are performed to obtain the pre-selected range.

Patentansprüche

1. Niederdruck-Quecksilberdampf-Entladungslampe, die einen rohrförmigen nicht-geraden Glasmantel mit einem gebogenen Abschnitt, der nach einem Beschichtungsschritt gebildet ist, Mittel zum Ausbilden einer Entladung, eine die Entladung aufrecht erhaltende Füllung aus Quecksilber und einem Inertgas, die innerhalb des Mantels eingeschlossen ist, und mehrere Seltenen-Erden-Leuchtstoffschichten innerhalb des Glasmantels aufweist, wobei jede der mehreren Leuchtstoffschichten (1) aus Seltenen-Erden-Leuchtstoffteilchen gebildet und (2) 1 bis 3 Teilchen dick ist, wobei die mehreren Schichten aus 2 bis 6 Schichten bestehen.

2. Lampe nach Anspruch 1, wobei jede der mehreren Leuchtstoffschichten aus der gleichen Seltenen-Erden-Leuchtstoffzusammensetzung besteht.

3. Lampe nach Anspruch 1 oder 2, wobei jede der mehreren Leuchtstoffschichten ein Beschichtungsgewicht von 1 bis 2mg/cm^2 hat.

4. Lampe nach einem der Ansprüche 1 bis 3, wobei der gebogene Abschnitt des Glasmantels einen innenseitigen Krümmungsradius von weniger als 15cm hat.

5. Lampe nach einem der Ansprüche 1 bis 4, wobei die mittlere Teilchengröße 1,5 bis 9µm (Mikron) beträgt.

6. Lampe nach einem der Ansprüche 1 bis 5, wobei die gesamte Überzugsdicke der Leuchtstoffschichten 4 bis 8 Teilchen dick ist.

7. Lampe nach einem der Ansprüche 1 bis 6, wobei die mehreren Leuchtstoffschichten ein gesamtes Beschichtungsgewicht von wenigstens 2,6mg/cm^2 haben.

8. Verfahren zum Herstellen einer Niederdruck-Quecksilberdampf-Entladungslampe, enthaltend die Schritte: Ausbilden einer geraden Glasröhre, Aufbringen von mehreren Seltenen-Erden-Leuchtstoffschichten auf der Innenseite der geraden Glasröhre, wobei jede der mehreren Leuchtstoffschichten (1) aus Seltenen-Erden-Leuchtstoffteilchen gebildet und (2) 1 bis 3 Teilchen dick ist, wobei die mehreren Schichten aus 2 bis 6 Schichten bestehen; nach dem Beschichtungsschritt die Glasröhre zu einem nicht-geraden Glasmantel geformt und der Glasmantel in eine Niederdruck-Quecksilberdampf-Entladungslampe eingefügt wird.

9. Verfahren nach Anspruch 8, wobei jede der mehreren Leuchtstoffschichten aus der gleichen Seltenen-Erden-Leuchtstoffzusammensetzung besteht.

10. Verfahren nach Anspruch 8 oder 9, wobei jede der mehreren Leuchtstoffschichten ein Beschichtungsgewicht von 1 bis 2mg/cm^2 hat.

11. Verfahren nach einem der Ansprüche 8 bis 10, wobei der gebogene Abschnitt des Glasmantels einen innenseitigen Krümmungsradius von weniger als 15 cm hat.

12. Verfahren nach einem der Ansprüche 8 bis 11, wobei jede der mehreren Leuchtstoffschichten ein Beschichtungsgewicht in einem vorgewählten Bereich hat, der vorgewählte Bereich 1 bis 2mg/cm^2 beträgt, wo die mittlere Teilchengröße 4 Mikron und die Teilchendichte 5g/cm^3 betragen, wo die mittlere Teilchengröße nicht 4 Mikron beträgt, wird der vorgewählte Bereich erhalten, indem 1 bis 2mg/cm^2 mit dem Verhältnis der mittleren Teilchengröße zu 4 Mikron multipliziert wird, wo die Teilchendichte nicht 5g/cm^3 beträgt, wird der vorgewählte Bereich erhalten, indem 1 bis 2mg/cm^2 mit dem Verhältnis der Teilchendichte zu 5g/cm^3 multipliziert wird, jedoch vorausgesetzt, daß, wenn die mittlere Teilchengröße nicht 4 Mikron und die Teilchendichte nicht 5g/cm^3 betragen, beide Berechnungen durchgeführt werden, um den vorgewählten Bereich zu erhalten.

Revendications

1. Lampe à décharge à vapeur de mercure à basse pression comprenant une ampoule en verre tubulaire non droite comportant une partie courbée formée après une étape de revêtement, des moyens pour réaliser une décharge, une charge de remplissage de mercure entretenant la décharge et un gaz inerte scellé à l'intérieur de ladite ampoule, et une pluralité de couches de luminophores de terres rares déposées à l'intérieur de ladite ampoule, chacune de ladite pluralité de couches de luminophores (1) étant composée de particules de luminophores de terres rares, et (2) ayant une épaisseur de 1 à 3 particules, ladite pluralité de couches consistant en 2 à 6 couches.

2. Lampe selon la revendication 1, chacune de ladite pluralité de couches de luminophores (1) ayant la même composition de luminophores de terres rares.

3. Lampe selon la revendication 1 ou la revendication 2, chacune de ladite pluralité de couches de luminophores ayant un poids de revêtement de 1 à 2 mglcm^2.

4. Lampe selon l'une quelconque des revendications 1 à 3, ladite partie courbée de ladite ampoule de verre ayant un rayon de courbure intérieur inférieur à 15 cm.

5. Lampe selon l'une quelconque des revendications 1 à 4, dans laquelle la dimension médiane des particules est de 1,5 à 9 microns.

6. Lampe selon l'une quelconque des revendications 1 à 5, dans laquelle l'épaisseur totale des revêtements des couches de luminophores est de 4 à 8 particules.

7. Lampe selon l'une quelconque des revendications 1 à 6, dans laquelle la pluralité de couches de luminophores a un poids total de revêtement d'au moins 2,6 mg/cm^2.

8. Procédé de fabrication d'une lampe à décharge à vapeur de mercure à basse pression comprenant les étapes consistant à : déposer une pluralité de couches de luminophores de terres rares à l'intérieur dudit tube en verre droit, chacune de ladite pluralité de couches de luminophores (1) étant composée de particules de luminophores de terres rares, et (2) ayant une épaisseur de 1 à 3 particules, ladite pluralité de couches consistant en 2 à 6 couches; après ladite étape de revêtement, donner au tube de verre la forme d'une ampoule en verre non droite, et incorporer ladite ampoule en verre dans une lampe à décharge à vapeur de mercure à basse pression.

9. Procédé selon la revendication 8, chacune de ladite pluralité de couches de luminophores ayant la même composition de luminophores de terres rares.

10. Procédé selon la revendication 8 ou la revendication 9, chacune de ladite pluralité de couches de luminophores ayant un poids de revêtement de 1 à 2 mg/cm^2.

11. Procédé selon l'une quelconque des revendications 8 à 10, ladite partie courbée de ladite ampoule en verre ayant un rayon de courbure inférieur à 15 cm.

12. Procédé selon l'une quelconque des revendications 8 à 11, dans lequel chacune de ladite pluralité de couches de luminophores a un poids de revêtement compris dans une fourchette présélectionnée, ladite fourchette présélectionnée étant de 1 à 2 mg/cm^2 lorsque la dimension médiane des particules est de 4 microns et la densité des particules est de 5 g/cm^3, lorsque ladite dimension médiane des particules n'est pas de 4 microns ladite fourchette présélectionnée est obtenue en multipliant 1 à 2 mg/cm^2 par le rapport de la densité des particules à 5 g/cm^3, à condition toutefois que, si la dimension médiane des particules n'est pas de 4 microns et la densité des particules n'est pas de 5 g/cm^3, les deux calculs sont exécutés pour obtenir la fourchette présélectionnée.

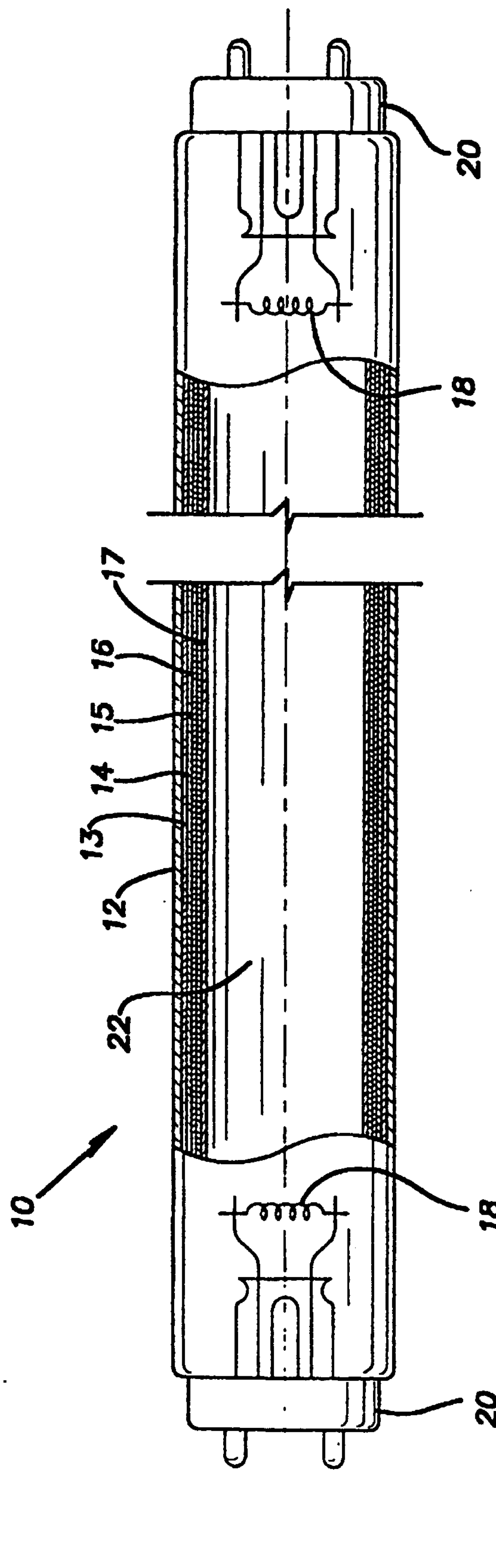

Fig.1

FIG. 2

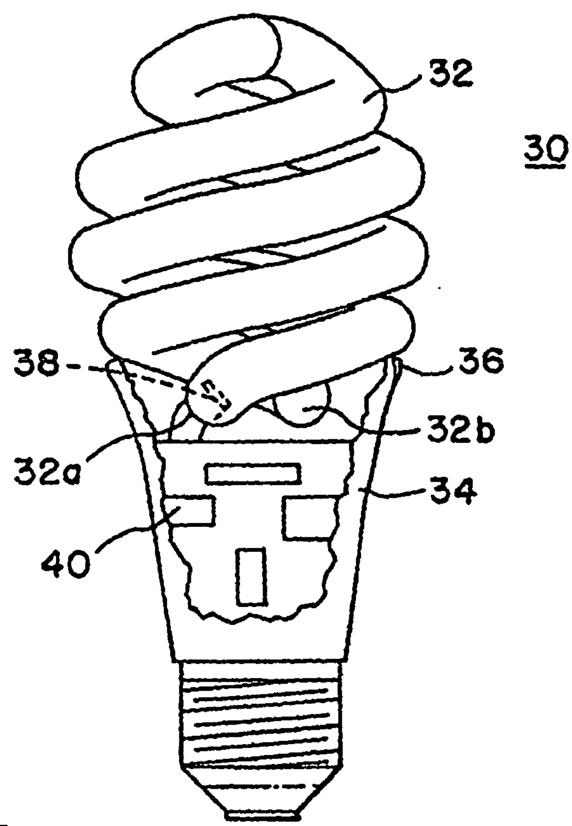

FIG. 3